lost: the facts

Your group members & Da Vinci's entire staff were on an airplane when disaster struck! Something strange happened on the plane and they've all been shipwrecked on a tropical island. Luckily it seems like a wonderful place, with bananas, coconuts, fish, and beautiful, lush scenery. Everything seems pretty great until we find that our fearless leader, Steve, has been murdered! There's no one else on the island – all of the students had an airtight alibi, so it had to be one of the other teachers that did it! No one feels comfortable coming back to school with a murderer in the midst – we can't sleep peacefully in our flimsy grass huts until the murderer is discovered.

We have watches, thermometers, and other simple tools, but no experts on murder investigations. The day Steve was murdered, all of the teachers were walking around the island, collecting supplies and noting its features, in hopes the information would help us figure out our location. Your group was working on a boat at a beautiful spot nearby, with a crystal-clear view of the volcano. It turns out that all teachers walked by your group, went up the volcano, passed by the spot where Steve's body was found, and checked in with your group afterwards. Since as Da Vinci Science students, you take such great records of everything, you have at time log of when each teacher visited you.

After investigating the place where Steve was killed, you realize it's a creepy place on the island that is unusually cold, 17° C. Could it be the strange monster from the forest?

Ms. Murday had a hunch that knowing the body temperature would help determine the time of death. So, at 5:12 pm, she checked the temperature of Steve's corpse. It was 27° C.

Interesting – that's 10° C below normal.

Ms. Murday checked again, an hour later. At 6;12 pm, it was 24° C.

Finding the murderer will be our goal. It might take us a few days. (I hope you don't mind some sleepless nights...)

One more clue… this comes from Ms. Brown, "I read a lot of murder mysteries. In one of them, this detective says, 'A dead body cools off just like a hot cup of joe.' I don't know if that helps or not…"

exhibit a
data & mathematics

[Do each of these assignments in your group. You may turn in one report per group. It will be important later to be able to describe how your understanding of the problem changed over time, so each person should keep neat notes on the case.]

Because you will be using this data to back up your accusations/defense in the final deliverable, all of these questions should be typed and presented in a logical format for the jury to examine. This will be Exhibit A in your court case. Using Ms. Brown's clue from murder mysteries, let's work with a "hot cup of joe."

pre-experiment:

1. Predict after how long you think the coffee will be cold: _____. About what temperature is it when it's cold? Explain your reasoning!

2. If you were to graph temperature versus time for a cooling cup of coffee, what will the independent variable? The dependent variable?

3. Predict what kind of function your graph should look like (recall all the functions we learned about in the last project!): _____. In the space below, sketch a graph of the temperature versus time for a cop of coffee, using your predictions from Questions 1 & 2 and your personal experience with hot beverages. Be sure to label your axes.

"cup of joe" experiment

Since coffee was one of the drinks served on the plane, we have plenty of coffee on hand (thank goodness Ms. Cha found it!). As Science students, we can use thermometers to gather the most accurate information on the way that coffee cools off.

Ms. Kondo says "We need some numbers here." And she boils some coffee up over a campfire and you'll measure its temperature with the thermometers that Ms. Murday, Ms. Brown, Ms. Merritt, & Ms. Ichiroku found.

equipment required:

- ✓ School laptop (fully charged)
- ✓ LoggerPro Software
- ✓ 1 Vernier Temperature Probes
- ✓ 1 beaker
- ✓ Hot coffee

equipment setup: *Follow all instructions CAREFULLY!!*

1. Open LoggerPro and create a New Experiment.
2. Connect the temperature probes to the CH1 and CH2 ports on the Vernier Interface. Plug the USB cable into the front left USB port. The two probes should be listed as Temperature 1 and Temperature 2 in the bottom left of the screen.
3. Click on the Experiment menu and select "Data Collection". Change the length of time to *70 minutes* and select *60 samples/minute*.
4. Press Done and return to the data analysis screen.

experimental procedure:

1. Record the room temperature in degrees Celsius below (probe should NOT be in the water yet!).

   Room temperature T_s = _____ ^0C

   Time of day: _____ am or pm (circle one)

2. Measure 200 ml of hot coffee using the beaker and pour into a bottle you've found from the wreckage. Cover with the lid.
3. Insert the temperature probe connected to CH1 into the "cup of joe." Make sure the tip of the probe does not touch the walls or the bottom of the containers (use tape if necessary).
4. Wait until the temperature probes reach equilibrium with the coffee. **When the temperature readings stabilize and do not grow any longer,** press COLLECT to begin the data collection. The data collection will stop after 70 minutes. Save the file after completing the experiment!

data analysis:

1. Display the graph of your data on the computer. Qualitatively, describe the shape and behavior of the curve. What kind of function do you think closely approximates it and why?

2. Print out the separate graph for your "cup of joe." Choose an appropriate scale for the axes and make sure to label the axes correctly (you can do this after printing) – recall how you chose the independent & dependent variables earlier!

3. List some of your data points in the table below:

Minutes elapsed	Recorded temperature in °C
0	
1	
2	
3	
4	
5	
10	
15	
20	
25	
30	
35	
40	
45	
50	

4. Explain what will happen to the temperature of the water in each container after a very long time. What does that mean for the graph of the function?

   a. So is there an asymptote for this relationship? If so, what does it represent?

   b. How will the room temperature show up in your equation $y = a \cdot b^x + k$?

5. **finding an equation!** Now we need to find an equation that will mathematically model the way a cup of coffee cools. Use two points from your data set in the experiment, substitute values into the exponential function to create a system of two equations.

   a. First we want to find the value of *a*. We need to adjust for the *h* value and room temperature, so…

   a = _____ - _____ ➔ a = _____
   (initial coffee temp) (room temperature)

   Explain why you have to subtract the room temperature from the initial coffee temperature recorded.

   b. Use another point (x,y) from your table and your *k* value from #4 to solve for b.

   c. Using your answers from 4b, 5a & 5b, what is the equation that represents the temperature of coffee at any time? Remember that exponential functions can be of the form: $y = a \cdot b^x + k$

our equation for a cooling cup of coffee:

6. Create a table for your equation in #5c (you can just input your equation from #5c into a calculator).

Minutes elapsed	Estimated temperature in degrees C **(based on equation from #5c)**
0	
1	
2	
3	
4	
5	
10	
15	
20	
25	
30	
35	
40	
45	
50	

   a. How do these values compare to the ones from the experiment? Does your equation generate some decent approximations?

7. Graph the equation (using the table from #7) you found in #5c on top of the graph of your data that you printed. Label where you think the asymptote should be. **Be sure to attach this graph to your report.**
   a. Was your equation a pretty close approximation (based on the graph)? Justify your answer.

exhibit b

solving for steve's time of death

[Do each of these assignments in your group. You may turn in one report per group. It will be important later to be able to describe how your understanding of the problem changed over time, so each person should keep neat notes on the case.]

coffee experiment conclusions

1. Given what you've learned in the coffee experiment and the equation it generated, when will the temperature of the coffee be 27.8° C? Justify your answer by solving your equation for x from #5c.

2. What time did you start your experiment at? _____. Given your answer above, what time of day will the coffee reach 28° C.

solving for steve's time of death

Steve's dead body was lying near the viewing spot for the volcano, and it turns out that there was only one path going by that spot. So, after checking with each other, and remembering who passed whom, you all agree that the murderer was most likely one of the people at that spot right before or after the time of death.

some of the alibis:

- Mr. Anderson was wandering around looking for pretzels; Ms. Kondo was hungry so she joined him later.
- Ms. Murday, Ms. Ichiroku, Ms. Brown, & Ms. Merritt were looking for thermometers. Later in the day, Ms. McLean helped them look for berries.
- Ms. Cha, Ms. Garcia, & Sra. Hernandez were looking for coffee.
- Ms. Allegra was gathering coconuts; she was later joined by Erin.
- Mr. Jackson & Ms. Sy were still recovering from the plane crash and were helping out on the beach.
- Mr. McGregor was hanging out on the beach, drinking lemonade and enjoying the views.

your task:

1. Make a table for the facts we know about Steve's body temperature.

x (_____)	***y*** (_____)
??? (time of death)	
0 (_____ pm)	
1 (_____ pm)	
2 (_____ pm)	

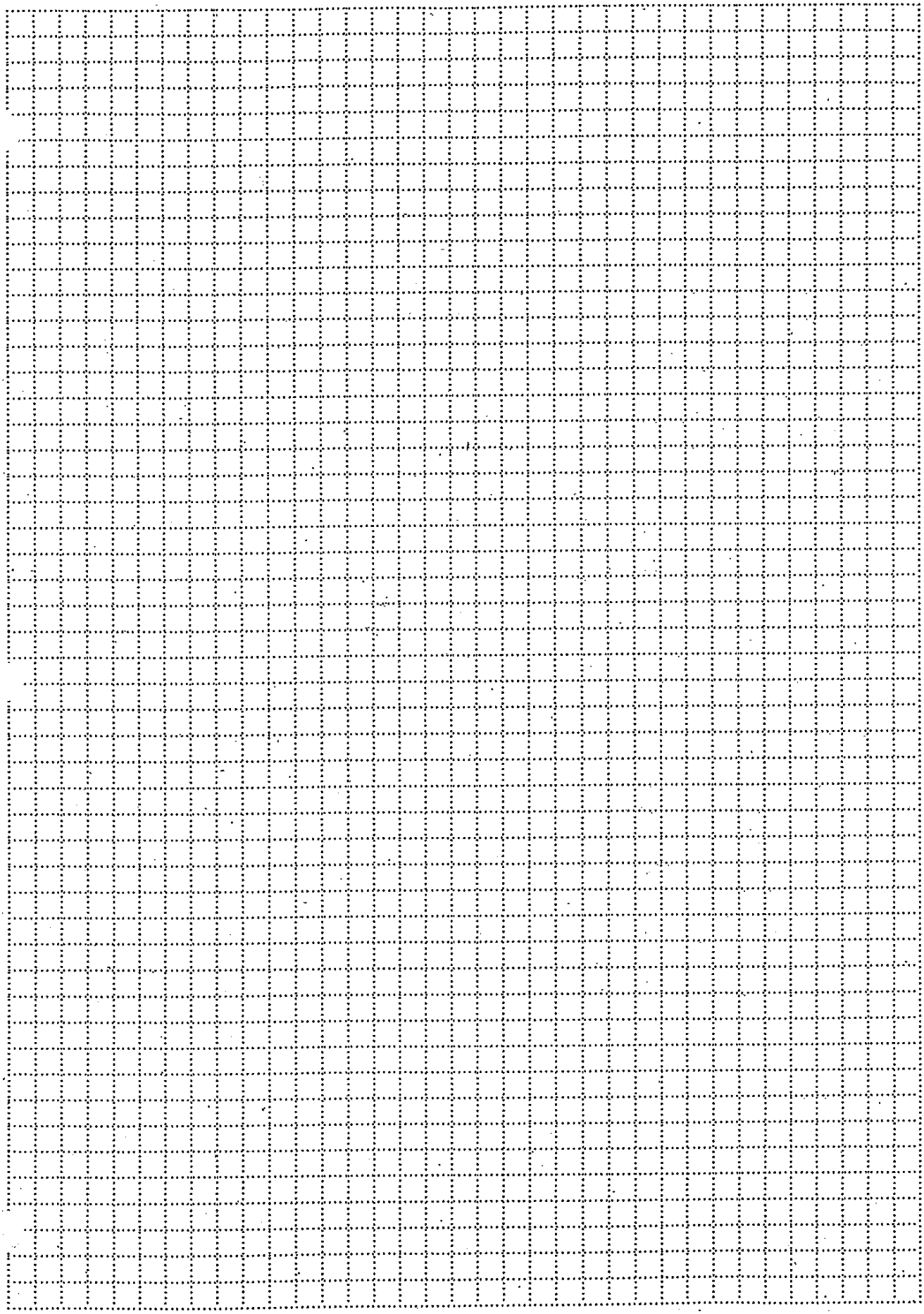
2. ***Using what you've learned from the coffee experiment*** and the facts from the case, develop an **equation** for the way Steve's body would cool (you can use the same procedure we used in #5 of Exhibit A).
    a. What will be the asymptote on Steve's body cooling graph?

    b. Find the value of *a* using temperature of Steve's body when we first checked it & ambient temperature where Steve was killed.

    c. Use another fact about Steve's body temperature that you know (from the table) and your other data/answers to solve for Steve's *b.*

our equation for steve 's cooling body:

3. Create a graph of the equation for Steve's body. Be sure to include this in your final report.



4. **when did he die?** What was Steve's body temperature when he died (examine the facts you've been given carefully)?? _____ Use this to solve your equation from #2 to determine how much time has passed since Steve was last alive. What time of day was that?

5. Using the table on the next page and the time of death, you'll know the most likely suspects.

time of death:

suspects:

da vinci science – student log of island activity

Name	Time up to the volcano viewing spot	Time returned from volcano viewing spot
Mr. Thomson	12:08 pm	2:47 pm
Mr. Besina	12:22 pm	1:38 pm
Lynn	12:24 pm	1:22 pm
Mr. Derbew	12:30 pm	2:45 pm
Mr. Montgomery	12:51 pm	1:25 pm
Frank	1:00 pm	2:30 pm
Erin	1:10 pm	2:45 pm
Ms. Allegra	1:30 pm	1:50 pm
Ms. Cha	1:43 pm	2:10 pm
Sra. Hernandez	2:08 pm	2:48 pm
Ms. Garcia	2:14 pm	2:51 pm
Mr. Anderson	2:45 pm	3:18 pm
Mr. McGregor	2:52 pm	3:01 pm
Ms. Murday	2:48 pm	3:22 pm
Ms. Kondo	3:57 pm	4:45 pm
Ms. Ms. McLean	4:08 pm	5:22 pm
Ms. Brown	4:17 pm	4:39 pm
Ms. Merritt	4:22 pm	4:37 pm
Ms. Ichiroku	4:26 pm	4:50 pm
Mr. Tostado	4:35 pm	4:59 pm
Mr. Perez	4:21 pm	4:49 pm
Ms. Sy	4:40 pm	5:02 pm
Mr. Jackson	4:48 pm	4:57 pm
Mr. Prendergast	5:04 pm	5:08 pm
Kat	5:05 pm	5:07 pm
Ms. Lodhy	4:56 pm	5:03 pm
Ms. Gire	5:33 pm	5:45 pm
Ms. Marquez	5:28 pm	5:42 pm

final deliverable
film presentation of evidence

[Do each of these assignments in your group. You may turn in one storyboard per group. It will be important later to be able to describe how your understanding of the problem changed over time, so each person should keep neat notes on the case & the film being made.]

final deliverable:

Because we are on an island and never know when we will be rescued, you're going to create a video to remember the facts of the case for when we return to Da Vinci. This will ensure that your important conclusions are not lost, even if the murderer (or crazy island smoke monster) strikes again!

Mathematics is the key to unlocking many secrets and proving facts beyond a shadow of a doubt. You are going to use it to prove the innocence or guilt of one of Da Vinci's finest teachers.

- ❒ **Your final deliverable is going to be the most *compelling* argument you can make on video to prove the guilt or innocence of a Da Vinci teacher or staff member.**

  Your teacher client: _____
  Guilty or Innocent: _____

- ❒ **You MUST include and fully explain mathematics that:**
  a. Refers to Exhibits A & B reports
  b. Explains the experiment with coffee to model Steve's cooling body.
  c. Develops the ***equation*** for Steve's body cooling.
  d. Shows the ***graph*** of Steve's body cooling.
  e. Explains ***solving*** the exponential equation for Steve's body and determines the ***time*** of death.
  f. (Optional) Solves the exponential equation for the ***temperature*** of Steve's body at a time when your teacher was near Steve's body.

- ❒ **Use the graph & equation (or even the table) to make your best closing arguments to the jury.** Explain we know the time of death and why that means your teacher is innocent or guilty.

- ❒ **Because of court limitations on closing arguments, your video MUST be *under 8 minutes long*.**